Conjunctive Water Use and Conjunctive Water Management

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INTRODUCTION

Conjunctive use of water from different sources for the purpose of crop production adds a new set of usage and management issues compared to single-source use of water. It requires that a set of decisions be made both at the application level and the water resource level that enable water users to make the best possible use of all available water.

To help clarify a discussion of conjunctive water use, the following division is made in terms of scale and the actors involved:

Conjunctive Use is defined as the actions of an individual, working in isolation to apply water from more than one source to meet crop water requirements, while

Conjunctive Management is the management of water resources either by a group of water users or by some external agency that affects a large group of water users simultaneously.

In many respects it is difficult to control individual use but we can learn and understand a lot from observing how individuals take advantage of multiple water sources to maximize their water productivity or farm level production. Conjunctive management, on the other hand, allows incorporation of water rights and water allocations to be added to the underlying pattern of water use by individuals so that wider ranging goals of equity, production and protection of water resources can be accomplished.

Underlying all of this, however, is the basic condition that a water user wants to increase production or productivity by being able to substitute or supplement the primary source of water. Typically, it is a strategy to minimize the risk of reductions in output due to shortfalls in either water quantity or quality of the primary source when the water user has no capacity to improve the reliability of the primary water source directly.

DIFFERENT TYPES OF CONJUNCTIVE USE

The term "conjunctive use" is an umbrella term that covers a wide range of combinations of water sources, the way in which they are combined, and indeed the purpose of combination. A brief review of these different categories is present below:

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Water Sources for Conjunctive Use

The majority of people will see conjunctive use as a combination of surface water supplies through canals and use of groundwater through pumping. However, this is just one of the several different categories of conjunctive use, and it is useful to remember that conjunctive use can potentially access four different water sources: canal water, groundwater, rainfall, and drainage water. Conjunctive use can cover any combination of two, three or even four of these water sources, and it is, therefore, important to be quite clear as to the nature of water sources involved, particularly when issues of conjunctive management are discussed. Examples are given in Table 1.

Table 1: Examples of Conjunctive Use Systems in South Asia

Primary Source	Secondary Sources	Selected Examples
Canal Water	Groundwater	Western Indo-Gangetic Plain (Rabi)
	Groundwater + Rainfall	Western Indo-Gangetic Plain (Kharif)
Groundwater	Canal Water	Tail end of many systems
	Drainage + Rainfall	Deltas in E. and S. India, Bangladesh
Rainfall	Canal Water	Sri Lanka/S. India (wet season)
	Groundwater	Eastern Gangetic Plain (Kharif)
	Drainage	Bangladesh, E. India
Drainage	Groundwater	Deltas in E. and S. India, Bangladesh
	Canal Water	Deltas in E. and S. India, Bangladesh

In almost every case it is possible to identify the primary water source and the secondary source or sources available to individuals that they can also use. The primary source is not necessarily the single largest use, but the one that determines the basic cropping pattern decided upon by an individual. For example, there are many parts of the Punjab in Pakistan where farmers use more groundwater than canal water, but it appears that the majority of farmers base their cropping decisions on the reliability of canal water supplies.

Combining Different Sources of Water

The way in which water from different sources is combined is also of critical importance to understanding opportunities for conjunctive management. Normally one of two different approaches can be adopted:

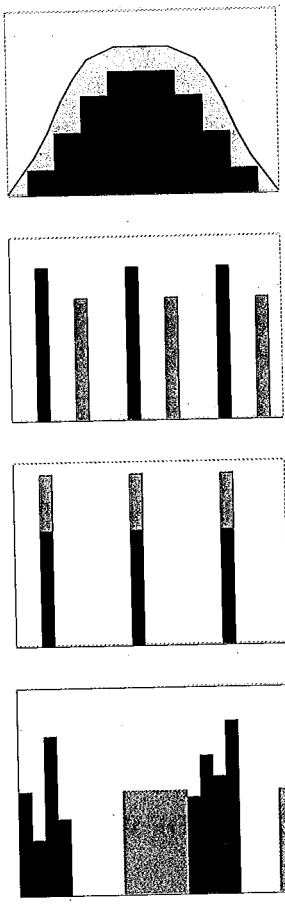
- Simultaneous use of water from different sources, so that water from different sources is mixed before application to the crop, and
- Separate use of water from the different sources, relying for a single source of water for each water application.

Simultaneous use is normally found when there are particular technical constraints present. They are normally either because the total flow of water from the primary source is inadequate to allow for proper irrigation and needs to be complemented with water from a secondary source to provide the required discharge, or because either the primary or secondary water source is of poor quality and needs dilution before it can be applied to the crop.

Separate applications are more common when there are significant fluctuations in the primary supply, often rotations in canal irrigation systems or breaks in the rainfall in rain-fed systems. In such cases an individual can manage the secondary source to maintain adequate soil moisture when there are deficiencies in the primary source.

We probably also need to distinguish between conjunctive use as a normal set of practices, where the water user expects to depend on at least two sources of water, and occasional use where there is a primary source on which the water user can depend for the majority of the time but may need access to a secondary source at unpredictable intervals.

Figure 1: Examples of different conjunctive use system



If these differences in the total range of water sources and the way in which they are combined are not fully understood it becomes very difficult to design and apply a more broadly based conjunctive management strategy. Schematic examples of different types of conjunctive use are shown in Figure 1, indicating the complexity of broader-scale management of water resources in conjunctive use environments.

Threats Arising from Uncontrolled Conjunctive Water Use

In the Pakistan context, we already see a number of consequences of uncoordinated management of water resources that are leading either to sub-optimal use of scarce resources or to threats to the sustainability of land and water resources. In large measure this has resulted from technological

developments that have enabled large numbers of farmers to purchase individual pump sets for exploitation of shallow groundwater.

Table 2 lists some of the more immediate threats that are currently being experienced, and where coordinated management of both surface and groundwater resources is needed. The threats can be seen as either the result of deliberate actions by water users, notably where inequity of access to water has developed or where farmers in fresh groundwater areas are overexploiting the available resources, or they can be indirect threats created by changed physical and hydraulic relationships in soil and groundwater.

Table 2: Threats arising from uncontrolled conjunctive use of surface and groundwater resources in Pakistan

Threat	Main Causes
Groundwater Depletion	Unregulated growth of shallow tubewells in areas of fresh groundwater
Soil Salinization	Excessive recycling of shallow groundwater leading to salt accumulation in upper layers of soil Pumping of poor quality groundwater to compensate for deficiencies in surface water supplies
Deterioration of Groundwater Quality	Leaching of salt accumulation into groundwater Depletion of shallow freshwater overlying saline groundwater Lateral intrusion from saline groundwater
Inequity of Access to Water Resources	Tail end water users forced to pump excessive amounts due to excessive use of surface water resources by head end farmers

Indirect threats are much more difficult to deal with because water users may not immediately perceive the negative impacts of their actions, or may even be unaware of such impacts because the symptoms are experienced by other water users in other locations. They normally have some element of soil or water quality involved which are harder for water users to accurately identify, and which may have a long-term cumulative effect rather than the more dramatic effects of physical water deficits.

THE NEED FOR CONJUNCTIVE MANAGEMENT OF WATER RESOURCES

The diversity of approaches to conjunctive use at field level presents a significant challenge for water resources managers at higher levels in the water management sector. Policy makers in the water sector have a responsibility to ensure that water resources are managed in such a way that there is a high level of effectiveness of resource use while still ensuring broader goals of equity of access to water by as many water users as possible, ensuring the sustainability of the water resource and protecting the environment from undesirable side-effects.

This multi-objective approach does not fit well into an environment where individual water users are only concerned with maximizing their individual objectives of production, profitability and food security. Nevertheless, it is important to try to match both local and national objectives as far as possible.

A significant weakness in the current institutional set up within Pakistan is that no single agency deals with all aspects of conjunctive use, and there are only weak mechanisms for coordination among the diverse range of agencies within the water sector. Yet conjunctive management is as much an institutional issue as a technical challenge.

If we examine the various threats indicated in Table 2, we see that not only are different conjunctive management systems required in different locations, depending on hydrology and geology, but also that in many locations management strategies need to be differentiated between wet and dry seasons.

Single-focus measures are unlikely to be particularly effective in an environment as complex as the ones we actually find. While there are advocates for several single-purpose measures such as groundwater regulation, reallocation of canal supplies to areas of poor quality groundwater, water pricing to restrict demand, or crop zoning to stabilize demand, none of them by themselves address the need to manage at least two different water resources simultaneously.

There is now considerable urgency for integrated conjunctive management in Pakistan. Water is increasingly short, and indeed some believe it is already allocated, the whole of it, between different sectors. Under these conditions each change in water use by one sector will automatically result in a direct impact on all other water users.

In Pakistan some conjunctive management techniques are used, notably response to rainfall involving reductions in canal supplies. By minimizing releases during wet periods maximum use is made of rainfall and some water is conserved for use at a later stage. But opportunities for major savings during wet periods are limited due to the length of canals and the lack of intermediate surface storage systems.

One area for fruitful investigation is to try to use the excessive surface supplies to recharge aquifers in those areas where there is a favorable recharge zone and canal supplies can be diverted when irrigation demand is less. To date this has not been investigated in a systematic manner.

Another opportunity is to make a thorough investigation of the minimum amount of canal water required in fresh groundwater areas, and try to divert the balance to areas where groundwater is of poorer quality. This requires careful modeling to ensure that reductions in good quality surface water supplies will not lead to soil salinization.

But the major step required at present is to develop an integrated database that allows all water resources managers, irrespective of their agency, to see what surface and groundwater conditions are, both in terms of quality and quantity, so that integrated planning of surface and groundwater resources can be made in light of actual conjunctive use patterns at field level.

Only when such an open database exists and is used by managers and planners can an effective conjunctive management strategy be developed. Through its "Benchmark Basin" program, IWMI, in collaboration with several agencies, is developing a prototype database for the Rechna Doab that will demonstrate the utility of shared access to a common database (Figure 2). This can lead to more effective decision-making both by managers and planners that will help lead to sustainable use of fragile water resources.

Figure 2: Front Page of the Integrated Database Under Development by IWMI Pakistan